with the writer's respects

PHYSICS AND PHYSIC.

THE THRUSTON SPEECH.

1869.

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THE THRUSTON SPEECH

UPON THE

PROGRESS OF MEDICINE,

DELIVERED IN THE

Chapel of Gonville and Caius College, Cambridge,

AT THE

WENDY COMMEMORATION,

ON MAY 11, 1869.

BY

ARTHUR RANSOME,
M.B. M.A.

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1869.

"Whenever the most perfect knowledge of Chemistry and Physics becomes the basis of rational Medicine, then, and not till then, Medicine will obtain the highest place among all the arts that minister to the welfare and happiness of man."

Dr Bence Jones, at the Nottingham Meeting of the British Association.

"If there can be said to be any extrinsic basis of Physic, such a basis must be afforded by Physics. The two words started in past times from the same idea, and, widely apart as they appear at the present day, they promise in the future to unite once more together, and every day seems to bring their union nearer and nearer."

The Laboratory, p. 366.

PHYSICS AND PHYSIC.

THE Art of Healing is served by many willing hands. The God of Medicine, like the Hindoo Vishnu, might have been represented as a benign and far-reaching power, with many arms outstretched to supply the wants of men. There is, in truth, no study that opens up so many avenues of knowledge, no research that makes use of so many of the rich veins of thought, connected with other regions of Science.

So many and various are the materials relating to Biology or the Science of Life, recently brought to light by scientific labourers of all kinds, that in attempting to give an account of the progress of medicine, the difficulty of the task will be, how to limit the range of our quest so as to give a sufficient explanation of the selected subjects, and to avoid a mere catalogue of names and discoveries.

I propose, therefore, at this time to speak only of the additions to Physiological Science which have been drawn within very recent periods from Chemistry, and the other Physical Sciences.

This age has truly been abundant in the materials of which science is built up—rich in well-attested facts, and in the principles resulting from their colligation: in facts,

which have been called the jewels of knowledge; in principles, the golden threads upon which they are hung.

Of all sciences, the greatest advance has perhaps been made of late years in chemistry and physics, and in its turn physiology has reaped abundantly the fruits of their labours.

Chemistry has always been a true friend to medicine: at first in the humble guise of a slave, wholly devoted to the discovery of some "aurum potabile," or elixir of life, which should bestow immortality and boundless wealth upon their possessor; but now as a mighty ally who permits a few only of her followers to search for the "Arcana" of the Kingdom of Life.

Until the last few years, however, chemistry has been mainly occupied with the *production* of what were called inorganic compounds, and with the *analysis* or breaking up of organic substances. It could not produce any of the myriad combinations which were constantly formed by the simplest animal or vegetable structures. By many, therefore, these organic bodies were looked upon as things apart, not to be put together by the unhallowed hand of the chemist, only to be brought into being when touched by the sacred Promethean flame of life.

At the present time the aspect of the field of chemical research is quite altered. It is true that the analysis of complex substances is not neglected. The tar products alone number many hundred, and include many bodies useful, not only in manufactures, but also in medicine. But the synthesis, or building up of new combinations formerly supposed to be the appanage of organized beings, is now going forward in most of the chief laboratories of chemistry.

A few years ago Wöhler broke the charm which was supposed to hedge round organic bodies, and commenced the great work of synthesis by producing urea, before then a product of animal life only.

Since this time many other organic substances have been made either directly from the elements or intermediately through an ascending series of alcohols and acids. Formic acid, a secretion of ants, and bodies as high in the scale as Benzole ($C_6 H_6$), have been produced by the direct union of the elements. And many other bodies have been made indirectly—such, for instance, as Alizarine, a component of madder dye; Coumarin, the odoriferous principle of the Tonka bean; Leucine, derived from Valeral-Ammonia, also a product of animal decomposition; and it has lately been reported that Neurine, the base of protagon, a substance extracted by Liebreich from the human brain, has been formed synthetically by Wurtz.

The methods by which these bodies may be made has been reduced to a system, by the labours of Berthelot and Wurtz, Frankland and Duppa. Thus, by substituting organic radicals for certain atoms of oxygen in organic ether, fatty products, with a carbon index as high as 12 ($C_{12} H_{24} O_3$)[1], have been obtained, and there is scarcely any limit to this production.

Much of this success is undoubtedly due to the modern views of the constitution of organic bodies; not only the *composition*, or the relative proportion of the simple elements in an organic compound, is now sought for; the mode of their grouping, their structure, is examined[2].

[1] Di-amyl-oxalic acid.

[2] Protagon the crystallizable essential constituent of the brain is a good instance of this mode of investigation. Its composition as ordinarily given is $C_{116} H_{241} N_4 PO_{22}$ but now chemists declare first that it is a combination of an acid, phospho-glyceric acid, with a base, neurine $= C_5 H_{15} O_2 N$, and then neurine can be artificially prepared by acting upon trimethylamine by Ethylene Oxide. It is an ammonium in fact, with three of its atoms of hydrogen replaced by methyl, and one by ox-ethyl, in other words, that it is a hydr-oxide of tri-methyl-ox-ethyl-ammonium; the type is thus shown:

$$\left.\begin{matrix} K \\ H \end{matrix}\right\} O; \quad \left.\begin{matrix} NH_4 \\ H \end{matrix}\right\} O; \quad \left.\begin{matrix} N(CH_3)_3C_2H_4\ (OH) \\ H \end{matrix}\right\} O = C_5 H_{14} N(OH).$$

I am indebted to my friend Dr Roscoe for this example.

Numerous substances are now known (Isomers, they are called), identical as to the proportionate number of their elementary atoms, but differing completely in structure and properties. At the present time many of these bodies are arranged in different groups according to their typical constitution.

A recent discovery has been applied by Mr Chapman to this investigation, and seems likely to aid very materially in finding out the essential structure of bodies.

Mr Chapman states[1] that an organic body, when carefully treated with a chromic acid solution, "will oxydize down to the stable representatives of the radicals it contains, and no further;" in other words, "it may be brought down to substances having the same carbon condensation as the radical it contains:" thus, if it were required to point out the essential differences between substances, isomeric in composition, containing, that is, the same percentage of the simple elements, this process would at once declare their true constitution.

It is scarcely too much to hope that by this and other methods, the structure of many animal and vegetable products may at length become known, and that their production by artificial means may come within the reach of Chemistry.

Even albumen itself, the principle of flesh, may yet be produced artificially, although the extreme complexity[2] of most of the forms of this substance will probably render its production very difficult.

[1] *The Laboratory*, p. 38.

[2] Dr Graham has pointed out the composite character of the molecules of colloid bodies like albumen.—"On liquid diffusion applied to analysis." *Phil. Trans.* 1862. Part I.

Dr Thudichum reckons the atomic weight of human albumenoids as varying between 1612 and 20,000, *eg.* the formula for blood-crystals is given as $C_{600}\ H_{966}\ N_{154}\ Fe\ S_3\ O_{177}$.—*Report on Researches intended to promote an improved chemical Identification of Diseases*, 1867, p. 234.

Here then is a wide field of research opened up by chemists; but very recently other important discoveries have been made in physiological chemistry proper. Foremost amongst them are the labours of Alexander Schmidt and Professor Brücke[1], on the substances (fibrino-plastic and fibrino-genic) which bring about the clotting of blood, the observations of Pettenkoffer and Voit, on the absorption of oxygen and the expiration of carbonic acid gas, at different periods of the day; and the exhaustive researches of Dr Schunck[2] and Dr Thudichum[3] on the chemistry of the urine.

Within the last few years also the field of experimental operations has been greatly enlarged, by the introduction of new instruments and methods of enquiry.

By the aid of the telescope, astronomers have resolved the gyrations of nebulæ, and have brought the moon within a few miles of the earth; with the microscope, anatomists have unravelled all the most delicate textures of the body; and now, by means of tests of marvellous delicacy, chemists daily perform equal, if not greater, wonders. First amongst these arms of precision must rank the spectroscope, and the Nessler test for ammonia.

The spectroscope will give evidence of the presence of the 180,000,000th part of a grain of sodium[4], the 72,000,000th of a grain of lithium[5]. The Nessler test will show 1 part of ammonia in 20,000,000 parts of water[6].

By means of an ingenious adaptation of this latter test, Messrs Wanklyn and Chapman have shown how to determine with facility, the quantity of albuminous (organic) matter in potable water; and by the same method they can discover minute quantities of albumen set free by

[1] *Proceedings of the Imperial Academy of Sciences*, May 23, 1867.
[2] *Proc. of Roy. Soc.*, No. 95, 1867.
[3] *Report to medical officer of the Privy Council, &c.*
[4] *Elementary Chemistry.* Roscoe, p. 230. 1st Edit.
[5] *Croonian Lectures*, Bence Jones, p. 180.
[6] *The Laboratory*, p. 256.

different physiological and pathological processes—for instance, in healthy and diseased respiration. We may hope for abundant results from such a research.

The spectroscope is a joint gift from both chemistry and physics: the mysterious dark lines of Wollaston or Fraunhofer's spectrum, which must be so familiar to many here, have been shown to be variously illuminated by incandescent chemical substances; and by the great genius of Kirchhoff and Bunsen they have been made to bear witness to the presence of these substances, when inconceivably small in quantity.

By a natural, but not the less wonderful sequence, they have enabled men to create a chemistry of the sun and of the stars, and have detected the presence of 15 of the mundane elements in the sun, and of 8 in the stars, nebulæ and comets [1]. They have even demonstrated the varying density of the photosphere of the sun, and have declared the composition of its rose-tinted flames [2].

The spectroscope has also watched the conflagration of a world whose parallax the astronomer could not measure, and has noted the degree and nature of its combustion, by the waxing or waning of its light [3]. In hearing of such achievements as these, may we not say with Coleridge, "In wonder all philosophy begins, in wonder it ends, and admiration fills up the interspace"?

Whilst, however, some have thus been searching the universe, others have turned the same instrument, the spectroscope, towards the minutest recesses of the micro-

[1] The elements found in the Sun are hydrogen, sodium, barium, copper, magnesia, aluminium, iron, manganese, chromium, cobalt, nickel, zinc, titanium, strontium, and cadmium.—*Six Lectures on Spectrum Analysis*, App. C. Roscoe.

In the star Aldebaran, bismuth, antimony, mercury, tellurium, iron, hydrogen, sodium, magnesium.—*Ibid.* p. 236.

[2] Norman Lockyer.—*The Student.*

[3] Huggins, W. and Miller, W. A. on the Spectrum of a New Star in Corona Borealis.—*Proc. Roy. Soc.* xv. 146.

cosm of the human body. And it has here done service, which in practical importance to mankind may perhaps rank with any of its astronomical triumphs. In the first place, the Lucasian Professor of Cambridge, Mr Stokes[1], has applied the instrument to the detection of the two forms of the colouring matter of the blood, the purple and the scarlet cruorine, and already his method has been turned to account in medico-legal inquiries, aiding greatly in the search for the blood-stains of murder[2].

Dr Bence Jones and Dr Dupré have, by means of the spectroscope, determined the rapidity of the circulation of the blood, of the absorption of salts by different tissues of the body, and the extent and duration of their sojourn in the organism, and from these experiments they draw the important conclusion, that medicines when taken into the system pass rapidly into *every* texture of the body, taking with them whatever energy they may possess. It is however only possible for them to act in those parts in which they can share in the processes there going forward[3].

Dr Bence Jones has also shown[4] by means of the spectroscope that a fluorescent substance, quinoidine, exactly like quinine in most of its properties, exists in varying amount in most animal textures, and Dr Thudichum has recently communicated to the medical officer of the Privy Council still more surprising results, obtained with this

[1] *Proc. Roy. Soc.* XIII. 335.

[2] Sorby, Letheby, Hoppe Seyler, and E. Ray Lankester.

Dr Bird Herapath was the first to employ the micro-spectroscope in a medico legal inquiry. The case was that of Robert Coe, who was tried for the murder of John Davies at Aberdare. The stains were found on the handle of a hatchet, under the iron ring.

[3] Let me illustrate this for a moment by supposing a shower or sheet of alcohol to fall in every part of a room, in many places it would apparently not be present, no action would occur, where there was varnish it would act chemically on the resin, where fire was burning it would burn; and in our eyes it would act chemically, increasing the action there.—*Croonian Lectures on Matter and Force*, p. 89.

[4] *Lectures on the Application of Chemistry to Pathology and Therapeutics.*

instrument, combined with several new methods of decomposition of organic compounds (chemolysis, physiolysis, biolysis, patholysis[1]). By these means he thinks that he has separated several new fluorescent bodies, and modifications of albumen, and regards it as probable that some of the characteristic products of such diseases as tetanus and hydrophobia may be discovered by these processes.

It is not only as interpretations of the 'dark sayings' of nature, not merely as contributions to science, that the discoveries now detailed are interesting and important. All of them have a bearing upon the art of healing, and may serve at least to direct the treatment of disease; but chemistry gives still more direct aid to the therapeutist; it has added not a few contributions to the materia medica—new weapons to the physician's armoury. Every new substance discovered is, in fact, a possible remedy, and may ultimately be used to cure or alleviate disease. A few years ago no one would have supposed, that so recondite a substance as the Terchloride of Formyle would come to be used in medicine, and yet who is there now who would not recognise it under the name of chloroform, as one of the greatest boons ever given to mankind?

Within the last year or two this class of anæsthetic or pain-quelling medicines has been largely increased; not only has our old friend the nitrous oxyde or laughing-gas been pressed into the service, but also such compounds as the following: amylene, nitrite of amyl, the chloride, iodide, bromide, and acetate of methyl, methylic ether, the nitrite and nitrate of methyl, the tetra-chloride of carbon, and bichloride of methylene. All these substances have been tested by Dr B. W. Richardson, and some of them, given by inhalation or applied as spray, have been shown to possess valuable and distinctive properties as anæsthetics[2].

[1] *Report to Medical Officer of the Privy Council.*

[2] *Report of the British Association for the Advancement of Science*, 1867. p. 45.

Antiseptic substances, able to prevent both fermentation and putrefaction, have also greatly increased in number and in use in medicine. Chief amongst them are carbolic and sulphurous acids, and the hypermanganate of potash. As means of destroying infection, used according to Dr William Budd's direction, they are likely to prove of invaluable service. As external agents, also, in surgical cases, they have already been very useful, especially in the hands of Prof. Lister of Glasgow[1]. They illustrate the value of perfect rest in the cure of disease, preserving the surfaces with which they are brought in contact from the intrusion of zymotic germs, and also preventing the acrid alterations of the animal-juices, which would otherwise interfere with natural curative efforts. Their action will probably throw some light upon the true value of other applications, which have been in use for many ages, such as lunar caustic, zinc, lead, copper, &c.

We cannot speak so decidedly of the beneficial action of these antiseptics administered internally in the form of sulphites, carbolates, sulpho-carbolates, &c. Since the interesting observations of Dr Polli with putrescent injections, different attempts have been made to cut short the morbid fermentation of diseases by these drugs, but hitherto the progress of zymotic diseases has not been materially affected by their use. They may however still prove useful in some cases.

But chemistry is beginning gradually to enter still further upon the interpretation of the action of remedies.

Dr Snow was the first to propound a theory of the chemical action of anæsthetics, and Dr Bence Jones has greatly extended his observations, claiming to account for

[1] See Address on the Antiseptic System of Treatment in Surgery, *Brit. Med. Journal*, July 18, 1868.

the operation of many classes of medicines upon chemical and mechanical principles[1].

Still more recently Dr A. C. Brown and Dr T. R. Fraser in a remarkable paper, published in the *Journal of Anatomy and Physiology*, have pointed out the connection between chemical constitution and physiological action, especially referring to the action of the salts of the ammonium bases derived from strychnia, brucia, thebaia, codeia, morphia, and nicotia; and Dr W. H. Broadbent has attempted to explain their results, upon the theory of varying "chemical tension" of these bodies and their relation to the chemical tension of the different parts of the nervous system. We may probably look for good fruit from such labours.

Physics have accomplished for medicine almost as much as pure chemistry. Time would not suffice even for a list of its contributions. I must therefore pass over without notice the services which have been rendered by the thermometer, by the use of heat and cold as medicinal agents, and the employment of electricity and galvanism, both in physiological experiments and in medicine. I shall turn at once to the mention of pure molecular physics, which has recently made so great progress, and which is destined to play an important part in the explanation of physiological problems.

The so-called physical forces, heat, light and electricity,

[1] 'Rest and Motion may be taken as the two great aims of therapeutical actions; stimulants giving rise to the greatest increase of motion, and sedatives allowing the least motion, or the nearest approach to rest.'—Dr Bence Jones, *Croonian Lectures*, p. 84.

Perhaps we shall ultimately be able to estimate the increase or diminution of any one motion, which by affecting all the motions in a part or in the whole body constitutes disease. When the disease arises from increased action we shall restore that normal quantity and quality of motion in the body, on which health depends, by decreasing the motion, or adding to the resistance to conversion; and when the disease arises from diminished action we shall obtain the same result, by increasing the motion, or lessening the resistance to conversion.—*Ib. loc. cit.*

have been shown to be modes of motion of material particles. It is not surprising, therefore, that the "vital forces" should have been considered to be correlated to them, and that eminent physicists should have tried to reduce vital phenomena to manifestations of purely physical energies.

Whatever may be the result of these speculations, the principle of the conservation of energy is one that may assuredly be applied with great effect to the solution of many vital problems.

Physiologists have already calculated the equivalents of force which may be produced by the combustion of fuel in the body, and Dr Frankland has ascertained the heat value of many kinds of food.

On the other hand, M. Barral has given an approximate estimate of the different amounts of force lost in different ways[1].

Nor are these mere abstract investigations, without immediate practical application. To take one instance only—those who are now cast down by the many defeats which have lately befallen our University Boat in its contests with Oxford, might perhaps discover the true meaning of *over-training*, by applying practically the results obtained by Messrs Fick and Wisliscenius[2], and by noting the kind of food shown by Drs Frankland[3] and Haughton[4] to be the best adapted for sustaining prolonged muscular exertion. They would probably find that courage and nervous energy would be none the worse for the support of a properly devised dietary.

But many other questions have been brought under the

[1] Thus from 1 to 2 per cent of power is given out in the heat of the excrements; from 4 to 8 per cent in the heat of the breath; from 20 to 30 per cent in the evaporation of water from the surface; and from 60 to 75 per cent in conduction and radiation and mechanical work.

[2] *Phil. Magazine*, Vol. XXXI. p. 485.

[3] See Appendix (2) to the Croonian Lectures for 1868.

[4] *Address on the Relation of Food to Work.* Oxford Meeting of Brit. Med. Association.

domain of this branch of physics. The minute structure of many of the workings of the molecules of the body are directly concerned with this subject.

As early as the year 1866, Dr George Wilson, then professor of Technology in Edinburgh University, pointed out[1] the remarkable physical properties of the elements composing organized bodies, and especially mentioned phosphorus, nitrogen and iron, and their compounds, as instances of the 'mobility' and adaptation of these elements to the varied wants of the body.

Thus, phosphorus, in virtue of its changeableness, "may occur in the brain in the vitreous form, changing as quickly as the intellect or imagination demands, and literally flaming that thoughts may breathe or words may burn; or it may be present in the bones in the amorphous form, content, like an impassive caryatid, to sustain upon its unwearied shoulders the mere dead weight of stones of flesh." It is thus also "that the mobility of nitrogen makes it preeminently the modifier of the living organism; like a half-reclaimed gipsy from the wilds, it is ever seeking to be free again, and not content with its own freedom is ever tempting others not of gipsy blood to escape from thraldom.

Mr Herbert Spencer[2] also has recently extended these remarks to the chief organic compounds of the body, showing that both binary and ternary compounds are isomeric and polymeric to a high degree, and exhibit a low stability, readily decomposing when subjected to either physical or chemical influences. But it is to Dr Graham that we owe the chief advance in our knowledge of the subject.

He had long ago noticed the remarkable variations in the mobility of different gases—and now he has put forth his remarkable generalizations respecting the 'crystalloid' and 'colloid' constitution of bodies. I have elsewhere[3],

[1] *Edinburgh Essays* for 1857.

[2] Principles of Biology.

[3] On the Physiological Relations of Colloid Substances.

pointed out the relation of his researches to physiology—their important bearing upon the subjects of absorption, digestion, the coagulation of the blood—upon cadaveric rigidity, and I may add, upon the many processes of fermentation and putrefaction.

In his method of dialysis also, we have at once an instrument of great power, and a means of classifying the phenomena which it brings to light.

All these researches are important aids to the study of physiology, and throw light upon the physical conditions of life.

There are, in fact (as I have ventured before to point out)[1], four chief conditions of molecular action, all of which are constantly fulfilled by living organized structures.

1. The possession of a power of molecular attraction.
2. A loose aggregation of molecules.
3. Low chemical affinity.
4. Perfect purity of molecules.

These conditions are present in nearly all physiological processes; by living beings, freshly formed, or nascent, material is continually brought forth with its molecules free, untainted by any soil of extraneous matter[2], and it is at once presented to fluids containing substances for which it has more or less molecular affinity.

For the most part, again, this material is colloidal in its structure, and hence is both chemically indifferent, and with its particles loosely aggregated, and in a position to act powerfully without entering into chemical combination; and, as Dr Graham has shown, it is readily penetrated by gases and crystalloidal substances.

The so-called ferments are the most prominent and decided possessors of these properties, and probably owe their peculiar powers to this fact; and we can scarcely

[1] On some of the conditions of molecular action.—*Phil. Mag.* May 1867.

[2] See Tomlinson "On some effects of a chemically clean surface."—*Phil. Mag.* Oct. 1868.

doubt that similar molecular energies come into play in all the processes of life.

Drs Hughes Bennett and Montgomery have already obtained most important results in their investigations upon the molecular properties of protagon, and have shown that under certain conditions it may be made to assume the forms of organized structures. It is very interesting to place these researches side by side with those of Dr Lionel Beale upon the formation of dead "formed material" by living "germinal matter."

Dr Bennett[1] considers that many of the earliest forms of infusorial life may be made to arise at will by carefully attending to these conditions, and he quotes the observations of several continental physiologists in support of his conclusions. These investigations are, however, still *sub judice*, and need to be put to most searching proof before they can be accepted; although for the present Mons. Pasteur, the great opponent of the theory of spontaneous generation, may be unable to overthrow the results of Bennett, Pouchet and others.

These, then, are some of the many points at which chemistry and physics invade the territory of physiology and medical science. I must not now trespass longer upon your time. Sufficient has perhaps been said to show their intimate relations, and to urge those who are entering upon medical studies, to make practical acquaintance with these important branches of knowledge. Some may even be encouraged themselves to attempt independent lines of research, in order to raise another corner of the veil which conceals the mysteries of creation[2].

[1] *Popular Science Review*, Jan. 1869.

[2] In the study of Natural Science a very high degree of mental training may be obtained. In proof of this it is only necessary to read the list of qualities which Dr Whewell ascribes to the Natural Philosopher and the terms of his 'Oath of Allegiance.'

"The discoverer of the Truth should indeed be ingenious and fertile in inventing explanations of the phenomena of nature, but he must also be dili-

In conclusion, let me say a few words to those who dread what has been called the materialistic tendency of modern science, and who may have thought that, in fore-casting the future triumphs of physiology, I have entered upon ground which ought to have been sacred.

There are not a few persons who still think that in seeking to know how the animal body is built up, and in imitating some of its actions, we are in danger like Frankenstein of constructing a monster, which will ultimately destroy our most precious faith in God and in spiritual things.

To these objections I would answer in the words of the author of the *Religio Medici*, "There is no danger to profound these mysteries, no *sanctum sanctorum* in philosophy[1]."

"I call the effects of nature the works of God, whose hand and instrument she only is; and therefore to ascribe His actions to her is to devolve the honour of the principal

gent and careful in comparing his hypotheses, ready to abandon his invention as soon as it appears that it does not agree with the course of actual occurrences.

"This constant comparison of his own conceptions and supported with observed facts under all aspects, forms the leading employment of the discoverer; this candid and simple love of Truth, which makes him willing to suppress the most favourite production of his own ingenuity as soon as it appears to be at variance with realities, constitutes the first characteristic of his temper. He must have neither the blindness which cannot, nor the obstinacy which will not, perceive the discrepancy of his fancies and his facts.

"He must allow no indolence, or partial views, or self-complacency, or delight in seeming demonstration to make him tenacious of the schemes which he devises, any further than they are confirmed by their accordance with nature. The framing of hypotheses is, for the inquirer after truth, not the end, but the beginning of his work. Each of his systems is invented, not that he may admire it and follow it into all its consistent consequences, but that he may make it the occasion of a course of active experiment and observation. And if the results of this process contradict his fundamental assumptions, however ingenious, however symmetrical, however elegant his system may be, he rejects it without hesitation. He allows no natural yearning for the offspring of his own mind to draw him aside from the higher duty of loyalty to his sovereign, Truth; to her he not only gives his affections and his wishes, but strenuous labour and scrupulous minuteness of attention."—Whewell, *Novum Organon Renovatum*, p. 80.

[1] Sir Thomas Browne, *Religio Medici*, Part I. Sect. XVI.

agent upon the instrument; which if with reason we may do, then let our hammers rise up and boast they have built our houses, and our pens receive the honour of our writings[1]."

There is small reason to fear that we shall ever know too much of that 'chime of restless motion[2]' which we call life.

We may, indeed, watch the orderly evolution of form, and measure the varied yet regular manifestations of power, and we may weigh, or even imitate some of the less recondite products of the laboratory of life; but we are yet very far from knowing anything of that strange concord of harmonious forces, which endows living matter with such singular properties. An amorphous speck of living gelatinous substance still baffles all the analytic power of both chemist and physiologist[3]: we have no need yet to sigh for new worlds to conquer.

With regard to the charge of materialism, I submit that in science we have nothing to do with such questions; as Professor Huxley has well said in a recent lecture on the Physical Basis of Life[4]: "Fact I know; and Law I know; but what is this necessity, save an empty shadow of my own mind's throwing." And, to quote again from another no less distinguished authority, Isaac Taylor, "If there be room at all for any hesitation or scepticism in relation to the existence of either, it is matter not mind that is in jeopardy[5]."

[1] *Ibid.*

[2]

Geburt und Grab,
Ein Ewiges meer,
Ein wechselnd Weben,
Ein glühend Leben.
GOETHE'S *Faust.*

When up some woodland dale we catch
The many twinkling smile of ocean,
Or with pleased ear bewildered watch
His chime of restless motion—
Such signs of life old ocean gives
We cannot choose but think he lives.
KEBLE.

[3] Darwin, *Variation of Animals and Plants*, 1868, p. 61.

[4] *Fortnightly Review*, Feb. 1869.

[5] The very ground of the assumption that the existence of an external

Let us, then, not imitate those who, with little faith, watch with fear the stormy conflict between some forms of Theology and Science; but let us remember with reverence, that underneath the *φαινόμενα* which we observe, there is the Hand of Him who is the Lord of all Power and Might, and who "upholdeth all things by the word of His Power."

world ought to be admitted as certain, without reasoning, is nothing else but a consideration of the laws or constitution of the mind. Mind, therefore, and its elementary principles stands first in logical order; and the existence of matter follows, if not as an inference, yet as a truth not to be affirmed until after another has been granted.

The bearing of this controversy upon Christianity may thus be stated.

The doctrine of the materialist, if it were followed out to its extreme consequences, and consistently held, is plainly atheistic, and is therefore incompatible with any and with every form of religious belief. It is so, because, in affirming that mind is nothing more than the product of animal organization, it excludes the belief of a pure and uncreated mind, the cause of all things; for if there be a supreme mind, absolutely independent of matter, then, unquestionably, there may be created minds, also independent of matter.

But if the materialist is ready to admit, as he usually does, the divine existence, and the pure spirituality of the divine nature, and if he professes to mean nothing more than that created minds are in fact always embodied, and that, apart from some material structure or aninal organization there is no consciousness or activity, then, and in this sense understood, materialism becomes a doctrine of little or no importance to our faith as Christians, for it may consist well enough with what is affirmed in the scriptures concerning the immortality of man, the resurrection, the intermediate state, and the existence and agency of invisible orders.—Isaac Taylor, *Physical Theory of another Life*, p. 14. (Bell and Daldy, 1866.)

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